EXTRUDER

The invention relates to an extruder pursuant to the introductory portion of claim 1.

Such an extruder is known, for example, from AT-E-40073B. It has a transfer region in which the material that is to be extruded is pressed out of the region of the extruder screw into threads provided in the extruder sleeve. By the transfer from the extruder screw into the region of the extruder sleeve, and back, the mixing of the starting materials is to be improved, which represents an important qualify feature of the extruded material. To avoid losses, the cross-sectional areas of the flow channels are precisely coordinated, and the extruder screw runs exactly in the extruder sleeve, with the exception of the structurally required gap of, for example, 100µm in conformity with the bearing play and the bending of the extruder screw during the rotation and stress.

It has also been proposed to change the flow cross-section in a defined manner in order to generate shear flows that are intended to improve the mixing. By reducing the cross-sectional surface there results, with rubber mixtures, which to this extent act like Newton's liquids, an elongated flow that corresponds to an acceleration of the mixture in an axially parallel direction of the extruder. However, this unfortunately results in a reduction of the retention time of the extruded

material in the extruder. The discontinuous pitch in the screw lands of the transfer mixture region to this extent reduces the homogenization; the temperature behavior also becomes worse. The discontinuous pitch is therefore only well suited for rubber mixtures that are easy to process.

In contrast, it is an object of the invention to provide an extruder pursuant to the introductory portion of claim 1, the temperature distribution and homogenization capability of which are improved even with exacting mixtures such as natural rubber.

This object is inventively realized by claim 1. Advantageous further developments are provided in the dependent claims.

Pursuant to the invention, it is particularly expedient that, due to the provision of a transfer gap, a shear flow profile is produced that at the same length of the extruder offers a significantly improved homogenization. Due to the inventively induced elastic or shear flows, there is effected in a defined manner an improved thorough mixing, which makes the temperature level significantly comparable. Colder regions of the mixture can flow into the inventive width gap. The polymer chains that are present there are inclined to slide along one another and to thereby be heated in an efficient manner.

Pursuant to the invention, the retention time of the mixture in the extruder is clearly increased, whereby the length of the retention time

can be controlled in a defined manner via the dimensioning of the inventive width gap.

In an advantageous embodiment of the invention, it is provided that the gap be provided with respective inlet or leading inclines that further improve the tendency of the material to flow in. The angle and the precise configuration of the inlet inclines can be adapted over a wide range to requirements.

Pursuant to the invention, the transfer is preferably effected using a linear characteristic. It is to be understood that instead of such a characteristic, it is also possible to select a characteristic that deviates from a linear course, for example a characteristic according to which the increase is negative in short regions, in other words, the flow cross-section of the flow channels of the extruder screw increases and in conformity therewith the flow cross-section of the flow channels of the extruder sleeve decreases.

Pursuant to the invention, it is particularly expedient that despite the same overall length of the extruder, the thorough mixing is considerably improved. This takes place with surprisingly simple means, whereby tests undertaken in conjunction with the invention have shown that the required power does not differ significantly from state of the art extruders. Due to the shear flow, plainly cold zones of

the extruded material are also heated up, so that also with regard to the temperature a homogenization results.

Further advantages, details and features can be seen from the following description of an embodiment with the aid of the drawings.

The drawings show:

Fig. 1 an extruder in an inventive embodiment, namely in a schematic cross-sectional view approximately in the middle of the transfer region;

Fig. 2 the extruder in the embodiment of Fig. 1, in a cross-sectional view at the end of the transfer region; and

Fig. 3 a schematic illustration of an inventive shear gap in a different embodiment, in comparison to the state of the art.

The extruder 10 illustrated in Fig. 1 has an extruder sleeve in which runs an extruder screw in a manner known per se. The cross-sectional view of Fig. 1 shows the transfer region. The extruder screw has ribs 16, between which extend flow channels 18. The extruder sleeve 12 also has ribs 20, between which extend flow channels 22. Pursuant to the invention, the width of the ribs 20 is increased, and in particular to a width that corresponds approximately to the width of the ribs 16 of the extruder worm or screw 14. In the illustrated embodiment, the width of the ridge is approximately half of the width of a flow channel 22.

Pursuant to the invention, there is furthermore formed between the ribs 16 and 20 a shear gap 24 that has a width of about 3% of the diameter of the screw. In combination with the lengthened or extended ridge width there thus results a shear gap 24 in which the extruded material is intensively and thoroughly mixed. It is to be understood that the width of the shear gap 24 can be adapted over a wide range to requirements. For example, the shear gap can also be 5% of the diameter of the extruder, or, for example, merely 0.8%. The precise configuration also depends upon the number of the worm lands of the screw 14, in other words, upon the number of the ribs 16 that are distributed about the periphery of the screw. In the illustrated embodiment, eight sleeve ribs 20 are combined with four screw ribs 16. It is to be understood that the configuration and arrangement are adaptable over a wide range to requirements.

Pursuant to the advantageous embodiment of the invention illustrated in Fig. 1, each rib 16 and 20 has a facet or incline 26 and 28, which in the illustrated embodiment is configured as a rounded portion. These inclines 26 and 28 significantly improve the flow of the extruded material into the shear gap 24, so that even cold areas of greater viscosity pass easily into the gap, where they are heated up by the shear and elastic flows that are generated.

Here too it is to be understood that the precise configuration of the inclines 26 and 28 is adaptable over a wide range to requirements.

Fig. 2 illustrates how the extruder sleeve 12 and the extruder screw 14 are represented at the end of the transfer region. The flow channels 22 have a flow cross-section that corresponds to the sum of the flow channels 18 and 22 of Fig. 1. At the end of the transfer region, the flow channels 18 are reduced to zero. Also at this location, an inventive shear gap 24 is provided that has the aforementioned effects.

Subsequent to the transfer region there extends, in a known manner, a further transfer region in which the depth of the flow channels 22 is reduced, and parallel thereto the cross-section of the flow channels 18 is increased until the flow channels 22 have disappeared.

Fig. 3 shows how an inventive shear gap 24 can be configured. With this embodiment, the inclines 26 and 28 are embodied as bevels. Their width is approximately half of the width of the ribs 16 and 20. In this embodiment, the angle of inclination α_s of the incline 26 is approximately 15°, and the angle of inclination α_b of the rib 20 is also 15°. The width of the shear gap 24 is approximately half of the height of each rib 16 and 20, or one fourth of the sum of the heights of the ribs 16 and 20, the heights of which, of course, continuously change

throughout the transfer region, whereas the sum of the heights remains constant.

It is to be understood that instead of this width δ of the shear gap 24, a width of, for example, merely one tenth of the sums of the ribs could also be obtained.

For the comparison of the structurally dictated residual gap 30, Fig. 3 also illustrates, at the right, how this gap results in extruders pursuant to the state of the art. It can be seen that the residual gap can have a height of, for example, 2.5% of the sum of the heights of the ribs. In contrast, pursuant to the invention the region of increased shear is increased in a significant and defined manner, resulting in the inventive effects.